Utility Management Series for Small Towns

Leakage Control Manual

UN-HABITAT
FOR A BETTER URBAN FUTURE

Volume
5

Leakage Control Manual

HS/ 124/12E
ISBN (Series) 978-92-1-133404-3
ISBN(Volume) 978-92-1-132537-9

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Acknowledgements

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FOREWORD

Municipal authorities and urban service providers are being increasingly challenged to deliver sustainable services in a rapidly urbanizing world with complex problems resulting from the interplay of climate change, resource constraints and the adverse effects of a sluggish world economy. The need to improve the coverage and efficiency of urban basic services, such as water supply, sanitation, energy, drainage and transportation, has never been greater.

It is now well recognized that the essential pre-condition for improvements in the delivery of urban services, is to establish effective and well run institutions within the framework of a policy environment that promotes investment, a commercial approach to service delivery, managerial autonomy and accountability to key stakeholders, including customers and the Government.

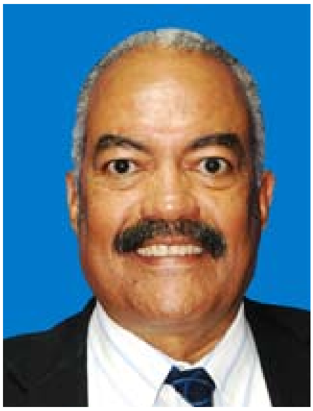
With its mandate to promote sustainable urbanization, UN-Habitat has been in the forefront of international efforts to build the capacity of urban water utilities to face the challenges of expanding access to water and sanitation while improving the efficiency of service delivery. Through its regional and national programmes and the Global Water Operators Partnership Alliance, UN-Habitat provides capacity building for urban water utilities with a focus on business planning, water demand management, improving billing and revenue efficiency, energy audits and planning for climate change adaptation.

The Lake Victoria Region Water and Sanitation Initiative is one of the regional programmes in Africa that has demonstrated the effectiveness of integrating capacity building for urban water utilities with modest investments to improve infrastructure. The first phase of the Initiative has now been completed with impressive improvements in extending access to water and sanitation while enhancing the managerial capacity and operational efficiency of the utilities in the ten pilot towns in Kenya, Uganda and Tanzania. The utilities which have benefited from the capacity building programme have experienced significant improvements in performance in key areas such as revenue enhancement, an expanded customer base and reductions in non-revenue water.

The six training manuals which are included in this Compendium of Training Materials are based on the practical experience of delivering the capacity building programme for urban water utilities in the Lake Victoria Towns. They encompass the key areas of utility management and operations and it is hoped that they will contribute to the knowledge base of training approaches and best practices in the water utility sector in small urban centers.

Joan Clos
Under-Secretary-General, United Nations
Executive Director, UN-Habitat

PREFACE



Small water utilities face unique challenges in delivering water and sanitation services to their customers. With a limited revenue base and few opportunities to benefit from economies of scale, they often suffer from severe skill shortages and a long legacy of underinvestment in infrastructure and capacity enhancement. To overcome these challenges, the small utilities need to maximize their operating efficiencies and ensure optimum utilization of their assets.

Since the year 2006, UN-Habitat has been working with national and regional partners in East Africa to implement the Lake Victoria Water and Sanitation Initiative (LVWATSAN) which seeks to address the water and sanitation needs of small secondary towns in the Lake Victoria Basin. A capacity development programme in utility management and operations has become an integral component of this Initiative, which was started in 10 towns and is now being expanded to another 15 towns in the 5 East African Countries which share the Lake Victoria Basin.

The implementation of LVWATSAN has generated a solid body of knowledge and experience in enhancing the capacity of small utilities to improve their financial viability and operating efficiencies. This experience has been applied to produce a series of Manuals which can be used as training materials to improve the operating performance of small utilities.

The Block Mapping Procedures Manual is part of a Compendium of Training Manuals for Small Water Utilities, produced by UN-Habitat in six (6) volumes, as follows:

Volume 1: Finance Policies and Procedures Manual
Volume 2: Customer Services User Manual
Volume 3: Block Mapping Procedures Manual
Volume 4: Water Audit Manual
Volume 5: Leakage Control Manual
Volume 6: Reduction of Illegal Water Use Manual

The Manuals were produced through a collaborative effort between UN-Habitat and the National Water and Sewerage Corporation of Uganda within the framework of a fast track capacity building programme in utility management and operations which targeted seven small utilities in the towns around Lake Victoria.

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ABBREVIATIONS AND ACRONYMS

CA	Cooperation Agreement
HDPE pipes	High-Density Polyethlyne pipes
hNi	Large Networks
Km	Kilometer
LRP	Leak Detection Programme
L	Leakage Rates
L/D	Length/Diameter ratio
Litres	Litres
M	Meter
Mm	Mili meters
MNF	Minimum night flow
NWSC	National Water and Sewerage Corporation
NRW	Non-Revenue Water
Psi	Pounds per Square Inch
P	Pressure

GLOSSARY

Water losses

The difference between system input and authorized consumption. water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones. Water Losses consist of physical losses and commercial.

Physical Losses

- ❑ Physical water losses from the pressurized system and the utility's storage tanks, up to the point of customers meter.
- ❑ Physical losses are at times called Real Losses or Technical Losses.

Leaks

This refers to water lost through leaks on the pipe network before the customer's meter.

Bursts

This refers to the water lost through bursts in the pipe network.

Over Flows and Leaks at Storage Tanks

This refers to the water lost through leaking overflows and or leakage of water storage facilities.

Non Revenue Water

Those components of System Input which are not billed and do not produce revenue. They equal to Unbilled Authorized Consumption plus Physical and Commercial Water Losses.

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CHAPTER 1

Background

A girl fetching water from a leaking pipe. Photo © UN-Habitat

Water Utilities have an important responsibility to provide safe and reliable supplies to their customers. Consumers, on the other hand also have a responsibility to ensure that they report any water leak observed in their area to the Utility. Both thr consumer and water utilities have a role in the leakage control process.

Its is important to control leakage at any point in the water channel system. Leaks if not addressed affect the reputation of an organization, diverts precious water from reaching the customers, and operation costs tend to go up.

The Lake Victoria Region Water and Sanitation Initiative has provided many useful lessons on the procedures and systems to be followed in addressing leakage control. If leakage is controlled there is a great positive impact to both the water utilities and the consumer. They both enjoy reduced operational costs, more water for consumption which translates to an increase in revenue, minimized water supply interruptions, reliable water quality among others.

Small urban utilities, with all the challenges that they face, cannot afford to lose water through leakage, and operate without a leak reduction unit. They are encouraged to systematically confront this problem by adopting the procedures outlined in this Manual.

1.1 Objectives

The objectives of the Leak detection Programme (LRP) are:

i. To reduce physical water losses through proactive visible-leak search campaigns and pressure regulation in all zones.
ii. To reduce physical losses through prompt leak repairs in the entire water supply system / network.

1.2 Manual Outline

Chapter one entails the background, scope and objectives of the manual.

Chapter two entails useful literature about leaks.

Chapter three describes the set up of the leak reduction unit and details the operating procedures.

Chapter four highlights the logistics required for implementation, including the human resource, skills and activities of the responsible leak detection team.

CHAPTER 2

Facts about Leaks

A leaking pipe. Photo © UN-Habitat

2.1 General information on leaks

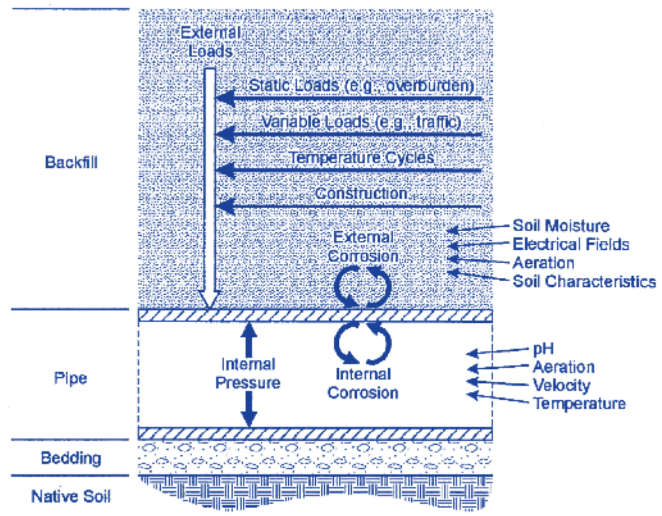
Important facts about leaks in a water distribution network:

- ❑ A small leak of one drop per second in the middle of a high way can cause tremendous trouble to the service providers, while a stuck consumer meter where volumes of water are being lost may cause no alarm at all to the public.
- ❑ Leaks affect the reputation of an organization negatively.
- ❑ Leaks divert precious water from reaching the customers.
- ❑ Leaks increase operating costs and are also a potential source for contamination of treated safe water
- ❑ Reduction of excessive losses is very likely the next cheapest water source after reduction of commercial losses.
- ❑ A leak of only one litre per minute corresponds to 525,600 litres per year.
- ❑ A leak of only one drop per second represents a water loss of 10,000 litres per year. *Source:* Environment Canada (www.ec.gc.ca)
- ❑ A water loss > 570 Litres per minute can result from a 25 mm diameter hole at a pressure of 2.8 bars. *Source:* Naval Facilities Engineering Service Centre (USA)
- ❑ The best indicator of physical water losses is water lost in litres/connection/day

2.2 Causes of Leaks and Bursts

- **Corrosion of internal and external surfaces of pipe network**. This occurs in metallic pipes as a result of chemical reactions.
- Specific events and situations
- **Excessive load/stresses from road traffic**. Road traffic is one of the leading causes of this. It is worsened if the pipes are on the surface or less than 3 feet deep.
- **Excessive water pressure and water hammer**. All pipes have specific pressure within which they should serve; once the pressure is exceeded the pipes naturally give way. This is worsened if the fittings are of a lower pressure rating as well. Excessive pressure should therefore be avoided, if possible serve water under minimum acceptable residual pressures.
- **Faulty workmanship and construction**. To compliment a good design quality work man ship should be observed if not then significant leaks at joints and fittings become evident.
- **Poor design (materials selection, sizing, and layout)**. The design of a system should suit the actual. If a system is under designed, it is likely to succumb to leaks. All pipes and fittings **MUST** be of the right pressure rating and standards as a whole.
- **A combination of factors**. A leak or burst can also be caused by a combination of two or more of the factors above.

Figure 1 A diagrammatic presentation of the causes of leaks



Source: Adapted from O'Day et al., 1986

2.3 Quantity of water lost through leaks

The volume of the water lost by leakage will depend largely on the characteristics of the pipe network, the leak detection and repair policy practised by the company, such as:

- ❑ Whether the soil allows water to be visible at the surface – Sandy soils are more porous in comparison to clay soils.
- ❑ The "awareness" time (how quickly the losing is noticed) – I am sure you have had experiences where you discover a leak and the community around tells you that the leak has lasted for

a long period of time. The earlier you notice the leak the better. The repair time (how quickly the loss is repaired) – This is worsened if procurement of required fittings has to be initiated after failure of a system.

- ❑ The pressure in the network.
  - The relationship between pressure and leakage is linear for metallic pipes (The higher the pressure the more water is lost)
  - The relationship between water loss and pressure is however exponential for plastic pipes (This is because the leaking hole widens as the pressure increases)

Pressure therefore has a direct impact on the volume of water lost.

2.3.1 Quantifying water lost through leakage

The volume of the water lost through leakage will depend largely on the characteristics of the pipe network, the proactive ness of leak detection and repair; it is also dependent on;

- ❑ The pressure in the network (Leakage Rate L (Volume/unit time) varies with Pressure^{N1} or $L_1/L_0 = (P_1/P_0)^{N1}$)
- ❑ Whether the soil/ground allows water to be visible at the surface or not
- ❑ The "awareness" time (how quickly the loss is noticed);
- ❑ The repair time (how quickly the loss is repaired)

Leakage is a function of the pressure and the area of leak and N1 factor (which is dependent on the material of pipe. L1/L0 = (P1/P0) N1)

A pilot on leakage - pressure relationship is conducted to determine the N1 factor. Remember that for large networks hN1 = 1 because of a mixture of various pipe materials, therefore enhancing a linear relationship between pressure and leak area.

The Non Revenue Water management manual therefore summarizes the volumes of water lost basing mainly on two factors i.e. Area of leak and pressure as illustrated on the next page.(see table below) From the table, the water loss per minute is multiplied by the response time to quantify total water lost.

Water lost per leak is therefore = Liters lost per minute x (Time of repair – time of occurrence) or average response time).

Pressure should be monitored or at least average pressure for the zone used in computations of water lost.

The table on the next page can therefore be used to estimate the water lost (Liters per minute) once the area of leak and pressure are established.

The table 1 is based on the formula Flow = 2.8xAreax square Root of (148x Preasure): Flow(gallons per minute), Area (Square inches) and Psi)

			Pressure in (Pounds per Square Inch (psi) and (Bars) ; 1 Bar = 14.5038 psi Flow in Gallons per minute and Litters per minute; 1 litter = 0.22 gallons									
			psi	Bars	psi	Bars	psi	Bars	psi	Bars	psi	Bars
			10.00	0.07	20.00	1.38	40.00	2.76	60.00	4.14	80.00	5.52
Area of leak Square Inches 1" Sq=645.16 sq mm	Area of leak mm Squared 1" = 25.4mm	Diameter of Circle (mm) A=(DSq)/4	Gallons per minute(gpm) or Liters per minute									
			Gallons	Liters	Gallons	Liters	Gallons	Liters	Gallons	Liters	Gallons	Liters
0.005	3.2258	2.00	0.50	2.27	8.00	36.36	1.10	5.00	1.30	5.91	1.50	6.82
0.010	6.4516	2.80	1.10	5.00	1.50	6.82	2.20	10.00	2.60	11.82	3.10	14.09
0.025	16.129	4.50	2.70	12.27	3.80	17.27	5.40	24.55	6.60	30.00	7.60	34.55
0.050	32.258	6.40	5.40	24.55	7.60	34.55	11.00	50.00	13.00	59.09	15.00	68.18
0.075	48.387	7.80	8.10	36.82	11.00	50.00	16.00	72.73	20.00	90.91	23.00	104.55
0.100	64.516	9.00	11.00	50.00	15.00	68.18	22.00	100.00	26.00	118.18	31.00	140.91
0.200	129.032	12.80	22.00	100.00	31.00	140.91	43.00	195.45	53.00	240.91	61.00	277.27
0.300	193.548	16.00	32.00	145.45	46.00	209.09	65.00	295.45	79.00	359.09	92.00	418.18
0.400	258.064	18.00	43.00	195.45	61.00	277.27	86.00	390.91	106.00	481.82	122.00	554.55
0.500	322.580	20.00	54.00	245.45	76.00	345.45	108.00	490.91	132.00	600.00	153.00	695.45
0.600	387.096	22.00	65.00	295.45	92.00	418.18	129.00	586.36	159.00	722.73	183.00	831.82
0.700	451.612	24.00	76.00	345.45	107.00	486.36	151.00	686.36	185.00	840.91	214.00	972.73
0.800	516.128	26.00	86.00	390.91	122.00	554.55	173.00	786.36	211.00	959.09	244.00	1109.09
0.900	580.644	27.20	97.00	440.91	137.00	622.73	194.00	881.82	238.00	1081.82	275.00	1250.00
1.000	645.160	28.70	108.00	490.91	153.00	695.45	216.00	981.82	264.00	1200.00	305.00	1386.36
1.100	709.676	30.08	119.00	540.91	168.00	763.64	237.00	1077.27	291.00	1322.73	336.00	1527.27
1.200	774.192	31.44	129.00	586.36	183.00	831.82	259.00	1177.27	317.00	1440.91	366.00	1663.64
1.300	838.708	32.70	140.00	636.36	198.00	900.00	280.00	1272.73	343.00	1559.09	397.00	1804.55
1.400	903.224	33.96	151.00	686.36	214.00	972.73	302.00	1372.73	370.00	1681.82	427.00	1940.91
1.500	967.740	35.00	162.00	736.36	229.00	1040.91	324.00	1472.73	396.00	1800.00	458.00	2081.82
1.600	1032.256	36.30	173.00	786.36	244.00	1109.09	345.00	1568.18	423.00	1922.73	488.00	2218.18
1.700	1096.772	37.42	183.00	831.82	259.00	1177.27	367.00	1668.18	449.00	2040.91	519.00	2359.09
1.800	1161.288	38.51	194.00	881.82	275.00	1250.00	388.00	1763.64	476.00	2163.64	549.00	2495.45
1.900	1225.804	39.56	205.00	931.82	290.00	1318.18	410.00	1863.64	502.00	2281.82	580.00	2636.36
2.000	1290.320	40.59	216.00	981.82	305.00	1386.36	431.00	1959.09	528.00	2400.00	610.00	2772.73
2.500	1612.900	45.38	270.00	1227.27	381.00	1731.82	539.00	2450.00	661.00	3004.55	763.00	3468.18
3.000	1935.480	49.71	324.00	1472.73	458.00	2081.82	647.00	2940.91	793.00	3604.55	915.00	4159.09
4.000	2580.64	58.42	431.00	1959.09	610.00	2772.73	863.00	3922.73	1057.00	4804.55	1220.00	5545.45

2.4 Benefits of Reducing Leaks

Leaks if not addressed are such a nuisance, They affect the reputation of an organization negatively, divert precious water from reaching the customers, increase operating costs and are a potential source for contamination of treated safe water. If leaks can be addressed, the following benefits are realized.

- ❑ Reduced operational costs– less travels to the field to repair leaks / bursts.
- ❑ More water availed for consumption and therefore increased revenue.
- ❑ Reliability of water supply – minimized water supply interruption due to repairs
- ❑ Reliable water quality as water can not get contaminated.
- ❑ Good public image for the corporation.

CHAPTER 3

Set up and operational procedures for a leak detection unit

A meeting convened to set up operational procedures. Photo © UN-Habitat

3.1 Introduction

Most water supply systems in the developing world do not have a systematic way of checking the pipe network and identifying leaks. They therefore depend on passive observations which include:

- ❑ responding to running or spouting water
- ❑ responding to low pressure identified by customers or during routine inspections.
- ❑ locate only obvious leaks or breaks (e.g. break of sufficient size or duration that water reaches the surface)

Relying on passive observation delays the awareness time translating into loss of more water.

Quick identification, repair and management of leaks is a very important aspect in reduction of NRW for any water supply business. This is because leaks are inevitable in one way or another. It is therefore very important to have a dedicated fully flagged team of staff to address leaks. This team is known as a Leak Reduction Unit or program.

3.2 Type of Leak Detection Units

Depending on the level of training and technology, the Leak reduction Unit may or may not have assorted leak detection equipment.

Note: *The activity of leak detection / identification should be separated from the leak repair exercise*

- ❑ Part of the team detects / identifies and sketches the location of leaks on given forms and the other repairs the Leaks)
- ❑ Alternatively if the staff to conduct leak detect are the same staff to repair the leaks, the two exercises must be separated i.e. the team should set aside time to conduct the leak detection / identification and the schedule repairs for another time.

3.2.1 Leak Reduction Unit (with no Leak Detection Equipment)

a) Staffing

A leak dedication /identification team should have a team leader and plumbers (Four to five plumbers in number is ideal for a moderately sized network (2000km of primary and secondary main pipes).

b) Tasks to be carried out by the leak detection team

- ❑ Leak searching: A combing of the whole network (on foot, bicycle or motor cycle) to identify any visible leaks.
- ❑ Sketching the leaks identified and reporting to the leak repair/ maintenance team
- ❑ Following up and submission of monthly report. The monthly report should capture
  - number of leaks reported through the month
  - number of leaks repaired
  - average awareness time (Acquired through asking community around the leak – how long the leak has existed)

- kilometers of pipe checked
- location of leaks versus frequency
- any other leak related information required by the service provider.

c) Requirements for leak identification

- ❑ Map and or good knowledge / understanding of the network. One must be able to reach the entire network from pumping main – transmission, storage, bulk transfer, distribution and customer service lines to the customer connection point. Often if maps are not available, this task is given to the plumbers who have wide knowledge on the network
- ❑ Transport – Bicycles/Motor cycles are ideal for this level of leak detection / identification.
- ❑ Forms – to ease repair and record keeping concerning leaks, it is paramount to sketch leaks on specific forms See appendix I.

3.3 Steps to follow when carrying out Leak Detection

For effective and efficient leak detection, the following procedures must be followed.

- ❑ Data collection i.e. network data, leak frequency and repair data, pipe rehab data, operation and maintenance of the network
- ❑ Network evaluation
- ❑ Physical leak detection (detection in the field)
- ❑ Planning and implementation of repair program then network maintenance and a rehabilitation program

3.3.1 Data Collection

Data collection is very key and the core parameters which varies depending on availability of data.

3.3.2 Network Evaluation

This is very helpful for purposes of knowing the water loss situation and prioritizing areas for conducting a leak detection campaign or intervention. There are five methods of network evaluation listed below, it is advisable to pick on the most suitable method, however in the worst case leak statistics per area /zone may be used to evaluate - indicate which areas are more prone to leaks

i. Water Audit

- ❑ A detailed accounting of all water into and out of a portion of the network based on meter records and flow measurements.
- ❑ Is typically applied to evaluate leakage in an entire network or in large portions of a network.
- ❑ Portions of water the network are isolated using valves (side benefit – location and repair of valves)
- ❑ As the flow in the distribution network are changing continuously, a water audit should be performed for at least a 24-hour period

ii. Zero-consumption measurement

It's a short term method that allows determination of real water losses. It can be applied only to sections of network that can be isolated without disruption of service. It requires field measurement of flow in pipes and all unmetered outlets are closed and inlet and outlet flows are compared to quantify leakage.

iii. Hydrostatic testing

It is similar to testing performed when a new pipe is being installed. Isolate a section of pipe, apply pressure higher than normal (but within limits) and measure pressure, failure to attain pressure indicates leakage.

This method is restricted in application because customers must be isolated during the test to avoid potential over pressurization.

iv. Continuous flow measurement (minimum night flow)

This is considered to be the best and quick method.

- ❑ usually used to determine the "minimum night flow (MNF)" in a network or a portion of a network
- ❑ the MNF is a quick indicator of leakage.
- ❑ the interpretation of MNF value is based on assumption that authorized water consumption is low at night, but that leak is fairly constant.
- ❑ MNF < 35% of average daily use – little leakage
- ❑ MNF > 50% of average rate - substantial leakage
- ❑ Most importantly if MNF >MNF0 then there are leaks. MNF0 Being the lowest acceptable MNF (determined by testing a typical area, without water leaks)
- ❑ conventionally a pilot study to determine acceptable nominal night use for a given setting Q_o is conducted, it entails; repair all the leaks in a typical hydraulic zone; measure consumption over night (mid night to 5am) and the determined nominal night flow rate = (Minimum night flow in cubic meters /Hour, Q_o). This is then used as a bench mark.
- ❑ prioritization of the campaign in the areas will then be dependent on the magnitude of characteristic minimum night flow in comparison to threshold value (Q_c-Q_o).

v. Passive observation

This method is mostly practiced in Kampala - Uganda, though with a few challenges faced by NWSC thisentails;

- ❑ responding to running or spouting water
- ❑ responding to low pressure identified by customers or during routine inspections.
- ❑ it is useful to locate only obvious leaks or breaks for example break of sufficient size or duration that water reaches the surface

Relying on passive observation delays detection of most leaks or breaks in the water supply system. To achieve tangible results, this method must be supplemented by other measurement methods.

3.3.3 Physical leak detection (detection in the field)

Physical leak detection entails determining the right / most suitable technology. There are several methods and equipment that can be used in leak detection, the choice of method /equipment is largely dependent on the nature of network one is dealing with and the availability of resources. These include;

- ❑ acoustic with correlation
- ❑ infrared Thermography
- ❑ chemical
- ❑ mechanical
- ❑ acoustic (with DFJunior/ground Microphone)

In comparison to the above information, this method was found to be the most suitable for the Kampala Network. This technique uses electronic listening equipment to detect the sounds of leakage. The equipment has a piezoelectric sensor, a high fidelity earphone set, a receiver box and a mechanical component in combination with the sensor (extension rods, a tip, a sensor support, cable attachments and a power magnet with 220Newton (20Kg force) power rating.

As pressurized water is forced out through a pipe, a leak loses energy to the pipe wall and to the surrounding soil area. This energy creates audible sound waves that can be sensed and amplified by electronic transducers/ piezoelectric sensor sound waves are evaluated to determine the exact location of the leak. Audible sound transducer is placed in contact with ground surface to assist in locating where the sound of leakage is louder. The sounds produced are dependent on a number of parameters namely; pressure (which should be 15 psi or more for sonic leak detection); pipe material, size and soil type –well compacted soils are a good conductor of sound; loose soils are not.

Appendices

Appendix 1

While you conduct leak detection/ identification and repair programs, it is paramount for the technical team to undertake measures that counter the causes of leaks. Below are such practices.

No	Cause of Leaks	Counter Practice
1	Corrosion of internal and external surfaces of pipe -network	• Use of HDPE pipes • Pipe replacement policy and implementation
2	excessive load/stresses from road traffic	• Lay pipe to depth of 3ft • Use strong sleeves at road crossings
3	faulty workmanship and poor quality materials, sizing and layout	• Ensure quality workman ship (capacity building) • Ensure that the materials received for field operations are of reliable quality
4	Excessive Pressure	**See details below**

Excessive water pressure and or water hammer

Management of pressure is one of the biggest questions often faced by water service providers. The problem is worsened if there is a big variation in topography of the area of water supply.

Relationship between pressure and leakage *(see table)*

This is not ideal as the area of leak increases with pressure.

Empirical relationship relates leakage and pressure for different types of network situations ($L1/L0 = (P1/P0)N1$) or $L1 = L0 \times (P1/P0)N1$

N1 is referred to as a scaling factor to account for different pipe and network characteristics

N1 - Scaling factor to account for different pipe and network characteristics.

- ❑ leaks from metallic pipes: N1 = 0.5
- ❑ small leaks at joints and fittings (Background Leakage): N1 = 1.5
- ❑ in exceptional cases of splitting of plastic pipes
- ❑ N1 could be up to 2.5
- ❑ large networks with mixed pipe materials tend
- ❑ towards a linear relationship of N1=1
- ❑ N1 varies with network conditions age, materials etc., it is determined by carrying out experiments in a given network.

For a large network with mixed pipe materials like the KW network N1 tends towards a linear relationship of N1=1

The question is what is adequate pressure?

The question often asked is – what is adequate pressure?

The desired pressure depends upon the following;

- ❑ Height to which water is required to be supplied,
- ❑ Fire fighting requirements
- ❑ Whether the supply is metered or not and
- ❑ Availability of funds.

The following pressures are considered satisfactory

Residential Districts

Up to 3 storey: 2kg/cm^2	= 1.96 Bars
3 to 6 storey: 2 to 4 kg/cm^2	= 1.96 to 3.92 Bars
6 to 10 storey: 4 to 5.5 kg/cm^2	= 3.92 to 5.39 Bars
Above 10 storey: 5.5 to 7 kg/cm^2	= 5.39 to 6.864 Bars

Commercial Districts

5 kg/cm^2 (4.9 Bars) where buildings exceed 3 storeys
4 kg/cm^2 (3.92 Bars) in areas with less risk and
3.5 kg/cm^2 (3.43 Bars) in thin built up areas

In towns with single storied buildings, a minimum of 7 meters (0.7 Bars) of residual pressure should be available.

Manual recommendations for minimum residual pressures

Single storey:	7m
Two storeys:	12m
Three storey Building:	17m

The fact is that in most cases, we have excessive pressure in the network in some areas and very low pressure in other areas.

The following pressures are considered satisfactory. Manual recommendations for minimum residual pressures, Distribution systems should not ordinarily be designed for residual pressures exceeding 22meters. Multi-storeyed buildings needing higher pressure should be provided with boosters. *(Water supply engineering by B.C Pumia Ashok Jain and Arun Jain)*

Practical Solutions (reducing excessive pressure)

- ❑ determine average desired pressure for different areas
- ❑ determine the current pressure
- ❑ then address the high pressure problem
  - There are two solutions to an existing network. Use of pressure break tanks and
  - the use of pipe fittings (Length/Diameter ratios)

In water engineering it is easier to work in terms of the equivalent height of water column, referred to by engineer's as head, sooner than repeating pressure calculations, especially if dealing with an already

existing problematic network. As water flows through pipes, tanks and fittings some energy is lost through friction and turbulence.

Solution

Pipeline fittings all provide a "point source" of head loss. The head losses are estimated by considering the equivalent length of pipe necessary to provide the same amount of head loss.

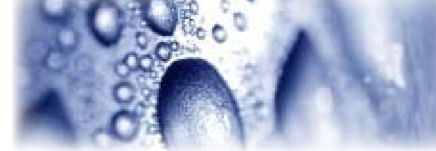
This is commonly described as the Length/Diameter (L/D) ratio.

Note: Isolated fittings need not be considered for a long pipeline, as the head loss that they generate is negligible compared with the normal head loss through the pipe.

Losses can be ignored for pipe lengths longer than 90m in the case of 3 inches and above (in this case **pressure reducing reservoirs** may be installed). Importantly, when several fittings are grouped close together the actual head loss is greater than the sum of the individual losses for each fitting. If practical, the close grouping of fittings should be avoided.

Equivalent Pipe lengths of Various Fittings ~L/D Ratios(Engineering in Emergencies ~ Appendix 16)

Pipe bend ~ 3 – 5 metre radius	5	Tee ~ flow from main to the branch	68
Pipe bend ~ 2 – 3 metre radius	10	Gate valve ~ fully open	7
Elbow	33	Non-return valve ~ flap type	50
Tee ~ flow in main line	27	Foot valve and strainer	70



Appendix 2

Chart used for Water Balance and computation of Non-Revenue Water

Non-Revenue Water System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Commercial Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies & Data Handling Errors	
		Physical Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Point of Customer Use	

This manual is part of a Utility Management Series for Small Towns. It can be used either as a training module to support the delivery of capacity building programmes in utility management and operations or as a reference manual to guide operations and maintenance staff in designing and implementing programmes to reduce the rate of Unaccounted-For-Water. When used by urban water utilities, the manual should be widely circulated to ensure that all staff and Supervisors involved/working in concerned Departments/Sections receive a copy. This will ensure a systematic and consistent approach to the implementation of an Illegal Water Use Reduction Strategy.

HS/ 124/12E
ISBN (Series) 978-92-1-133404-3
ISBN(Volume) 978-92-1-132537-9

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